

Natural Condition
Assessment for Low Dissolved Oxygen
Buckhorn Creek Unnamed Tributary
Southampton, Virginia

Submitted by

Virginia Department of Environmental Quality

June 2006

TABLE OF CONTENTS

Executive Summary	1
1. Introduction.....	4
2. Physical Setting	4
2.1. Listed Water Bodies	4
2.2. Watershed	5
2.2.1. General Description	5
2.2.2. Geology, Climate, Land Use.....	5
3. Description of Water Quality Problem/Impairment.....	8
3.1. Associated Mainstem and Tributary Site DO.....	8
4. Water Quality Standard	8
4.1. Designated Uses	9
4.2. Applicable Water Quality Criteria	9
5. Assessment of Natural Conditions affecting low DO	9
5.1. Preliminary Data Screen for Low Flow 7Q10.....	13
5.2. Low Slope, Swamps, or Wetlands	14
5.3. Instream Nutrients.....	15
5.4. Natural Seasonal DO Fluctuation.....	16
5.5. Impact from Point Source Dischargers	16
6. Conclusion	17
7. Public Participation.....	17
8. References	17
Appendix A (Glossary)	19

LIST OF TABLES

Table 1.	Impaired segment descriptions (Buckhorn Creek UT)	4
Table 2.	Climate summary for Holland, Virginia (Station #444044)	6
Table 3.	Land use in the Buckhorn Creek UT watershed.....	7
Table 4.	DO data collected by VADEQ on Buckhorn Creek UT at Rt 258	8
Table 5.	Applicable water quality standards.....	9
Table 6.	Instream nutrients of Buckhorn Creek UT, 5AXDN000.48.	16

LIST OF FIGURES

Figure E1.	Times series of DO concentrations at Buckhorn Creek UT at Rt 258, 5AXDN000.48.....	1
Figure 1.	Map of the Buckhorn Creek UT study area.....	5
Figure 2.	Land use in the Buckhorn Creek UT watershed	7
Figure 3.	Time series of DO Concentrations at Buckhorn Creek UT at Rt 258, 5AXDN000.48..	8
Figure 4.	Buckhorn Creek UT at Rt 258 Bridge, May 2006.....	14
Figure 5.	Buckhorn Creek UT at Rt 258 Bridge, May 2006.....	15
Figure 6.	Buckhorn Creek UT at Rt 258 Bridge, May 2006.....	15
Figure 7.	Seasonal variations in DO at Buckhorn Creek UT at Rt 258, 1996-1999... ..	16

Executive Summary

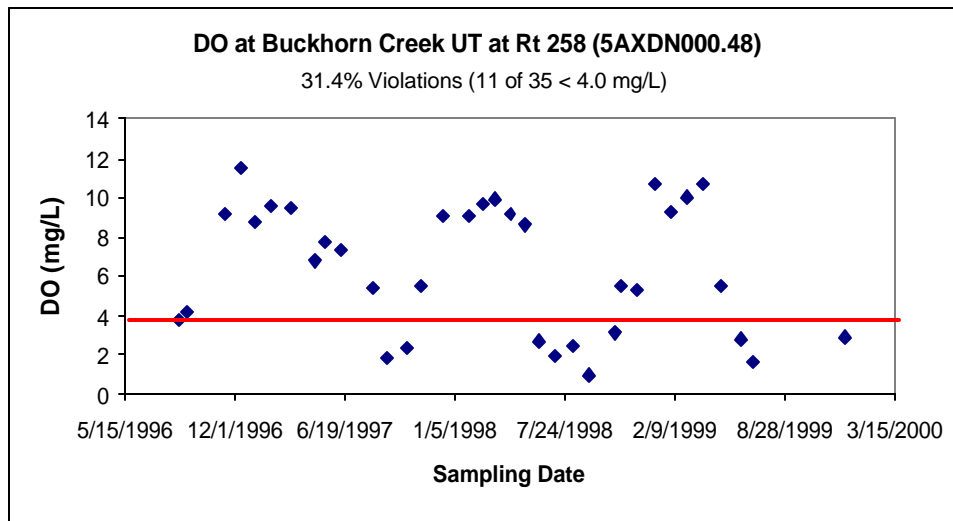
This report presents the assessment of whether low dissolved oxygen (DO) in an unnamed tributary to Buckhorn Creek (Buckhorn Creek UT) is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Buckhorn Creek UT is located in the Southampton County in the Chowan River and Dismal Swamp Basins (USGS Hydrologic Unit Code 03010203). The waterbody identification code (WBID) for Buckhorn Creek UT is VAT-K37R. There are 2.0 total stream miles in the Buckhorn Creek UT watershed (National Hydrography Dataset (NHD)).

The drainage area of the Buckhorn Creek UT watershed is approximately 1.91 square miles. The average annual rainfall recorded at Holland, VA is 48.76 inches. The watershed is approximately 1,226 acres in size, and is predominately forested (63.1 percent) and agricultural (15.9 percent). The agricultural area includes 11.8 percent row crop and 4.06 percent pasture/hay land. Other uses in the area are comprised of 2.61 percent open water, 8.63 percent transitional areas, 6.0 percent woody wetlands, and 3.77 percent herbaceous area.

The DO impaired segment is 2.0 stream miles of mainstem Buckhorn Creek UT from 1.52 miles upstream of the Rt 258 bridge to the VA/NC state line. An assessment of low pH due to natural conditions has been performed on the Buckhorn Creek UT watershed in a separate document.

Buckhorn Creek UT was listed as impaired on Virginia's 2002 303(d) Report on Impaired Waters, and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 2003, 2004) due to violations of the State's water quality standard for dissolved oxygen and pH. VADEQ collected a total of 35 DO data points, with 11 water quality standard violations (31.4%) at station 5AXDN000.48 from August 21, 1996 through December 15, 1999 (see Figure E1).

Figure E1. Time series of DO concentrations at Buckhorn Creek UT at Rt 258, 5AXDN000.48.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Buckhorn Creek UT must support all designated uses and meet all applicable criteria. Buckhorn Creek UT does not appear to support aquatic life use because of DO water quality standard violations.

VADEQ proposes a methodology for determining whether low DO originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Rosier Creek Watershed, Virginia." (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, rippleless waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. VADEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

- Step 1. Determine slope and appearance (presence of wetlands).
- Step 2. Determine nutrient levels and compare with USGS background concentrations.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

Before implementing this procedure for low DO, all DO data should be screened for flows less than the 7Q10. DO data collected on days when flow was less than the 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. If the 7Q10 is identified as 0 cfs, then all data collected under 0 cfs flow would be considered in the water quality assessment. Using a proportional drainage analysis, the 7Q10 at Buckhorn Creek UT is 0.02 cfs. Since no data points were collected during the dates with a 7Q10 less than 0.02 cfs, all data in the data set have been considered in determining the DO violation rate.

Buckhorn Creek UT from rivermile 2.00 downstream to the VA/NC border at rivermile 0.00 exhibits a low slope (0.15%) and large areas of forested land with swamps and heavy tree canopy. Decomposition of large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Buckhorn Creek UT exhibits low nutrient concentrations near or below national background levels in streams from undeveloped areas, which are not indicative of human impact.

Buckhorn Creek UT exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no permitted dischargers in the Buckhorn Creek UT watershed.

Based on the above information, a change in the water quality standards classification to Class VII Swamp Water due to natural conditions, rather than a TMDL, is indicated for Buckhorn Creek UT from rivermile 2.00 downstream to rivermile 0.00 at the VA/NC border, totaling 2.0 stream miles. If there is a 305(b)/303(d) assessment prior to the reclassification, Buckhorn Creek UT will be assessed as Category 4C, Impaired due to natural conditions, no TMDL needed.

VADEQ performed the assessment of the Buckhorn Creek UT low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. INTRODUCTION

Buckhorn Creek UT was listed as impaired on Virginia's 2002 303(d) Report on Impaired Waters, and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 2003, 2004) due to violations of the State's water quality standard for dissolved oxygen and pH. This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The pH impairment has been addressed separately from this document.

A glossary of terms used throughout this report is presented as Appendix A.

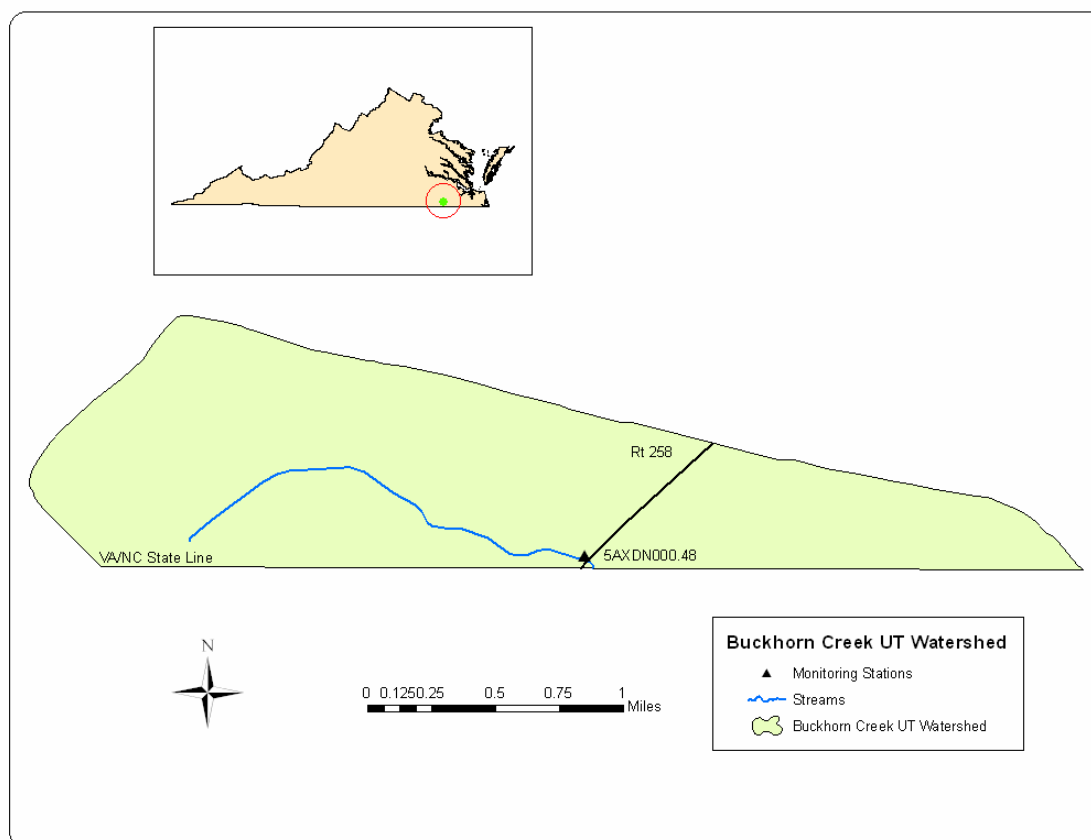
2. PHYSICAL SETTING

2.1 Listed Water Bodies

Buckhorn Creek UT is located in Southampton County in the Chowan River and Dismal Swamp Basins (USGS Hydrologic Unit Code 03010203). The waterbody identification code (WBID) for non-tidal Buckhorn Creek UT is VAT-K37R. There are 2.0 total stream miles in the Buckhorn Creek UT watershed (National Hydrography Dataset (NHD)). The impaired segment is 2.0 stream miles of mainstem Buckhorn Creek UT. This report addresses only the DO impairment. The pH impairment is reported in a separate document. The segment is described in Table 1 and Figure 1.

Table 1. Impaired segment descriptions (Buckhorn Creek UT).

Segment (segment ID)	Impairment (source of impairment)	Upstream Limit Description	Downstream Limit Description	Miles Affected
Buckhorn Creek UT VAT-K37R	Dissolved Oxygen pH (Natural Conditions)	1.52 miles above the Rt 258 bridge	VA/NC state line	2.0

Figure 1. Map of the Buckhorn Creek UT study area.

2.2. Watershed

2.2.1. General Description

Buckhorn Creek UT, located within Southampton County Virginia, is a minor tributary to Buckhorn Creek, near the border of North Carolina. It is approximately 2.0 miles long and flows west from its headwaters near the town of Riverdale, VA to its confluence with Buckhorn Creek, which then flows to the Chowan River in North Carolina. The watershed has an area of approximately 1.91 square miles. There is no continuous flow gaging station on Buckhorn Creek UT, however there is a USGS gage (#02051000) on North Meherrin River near Lunenburg, VA, with a drainage area of 55.6 mi². This gaging station was used for the 7Q10 data screen.

2.2.2. Geology, Climate, Land Use

Geology and Soils

Buckhorn Creek UT is in the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and

beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (<http://www.geology.state.va.us/DOCS/Geol/coast.html>).

Soils for the Buckhorn Creek UT watershed were documented utilizing the Natural Resources Conservation Service Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov>). Three general soil types were identified using this survey; the Levy series, the Nansemond series, and the Pactolus series. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (<http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi>).

The soils of the Levy series are very deep, poorly drained soils. These soils are located on marshes and in the floodplains of the lower Atlantic Coastal Plain. This series is primarily formed from fluvial sediments. The soils are typically silty clay and silty clay loam and permeability of these soils is very slow. The Levy series was formerly mapped as either swamp or fresh water marsh.

The soils of the Nansemond series are very deep and moderately well drained. Permeability is moderately rapid. These soils are located on marine terraces and stream terraces of the Atlantic Coastal Plain. The soils formed from parent materials consisting of alluvium and marine deposits. This series typically consists of fine sandy loam soils.

The Pactolus series are very deep soils consisting of sand to loamy sand. Drainage is moderately well to somewhat poor and permeability is rapid. This soil series was formed from sandy fluvial and marine sediments on Coastal Plain stream and marine terraces.

In the watershed, small percentages of other soil series were also found which include Kenansville, Rains, Alaga, Tetotum, Tomotley, Wahee, Dogue, Dragston, and Goldsboro series.

Climate

The climate summary for Buckhorn Creek UT comes from a weather station located in Holland, VA (Station #444044, Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html) with a period of record from 8/1/1948 to 3/31/2004 (Table 2). The average annual maximum and minimum temperature (°F) at the weather station are 69.9 and 47.2, respectively. The average annual precipitation is 48.76 inches.

Table 2. Climate summary for Holland, Virginia (Station #444044).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (°F)	49.5	52.2	60.0	70.2	77.9	85.0	88.4	86.9	81.5	71.9	62.8	52.8	69.9
Average Min. Temperature (°F)	28.3	30.4	36.8	45.1	54.5	62.6	67.2	65.6	59.3	47.4	38.8	30.9	47.2
Average Total Precipitation (in.)	3.95	3.46	4.0	3.25	3.99	4.09	5.51	5.77	4.52	3.70	3.13	3.40	48.76

Land Use

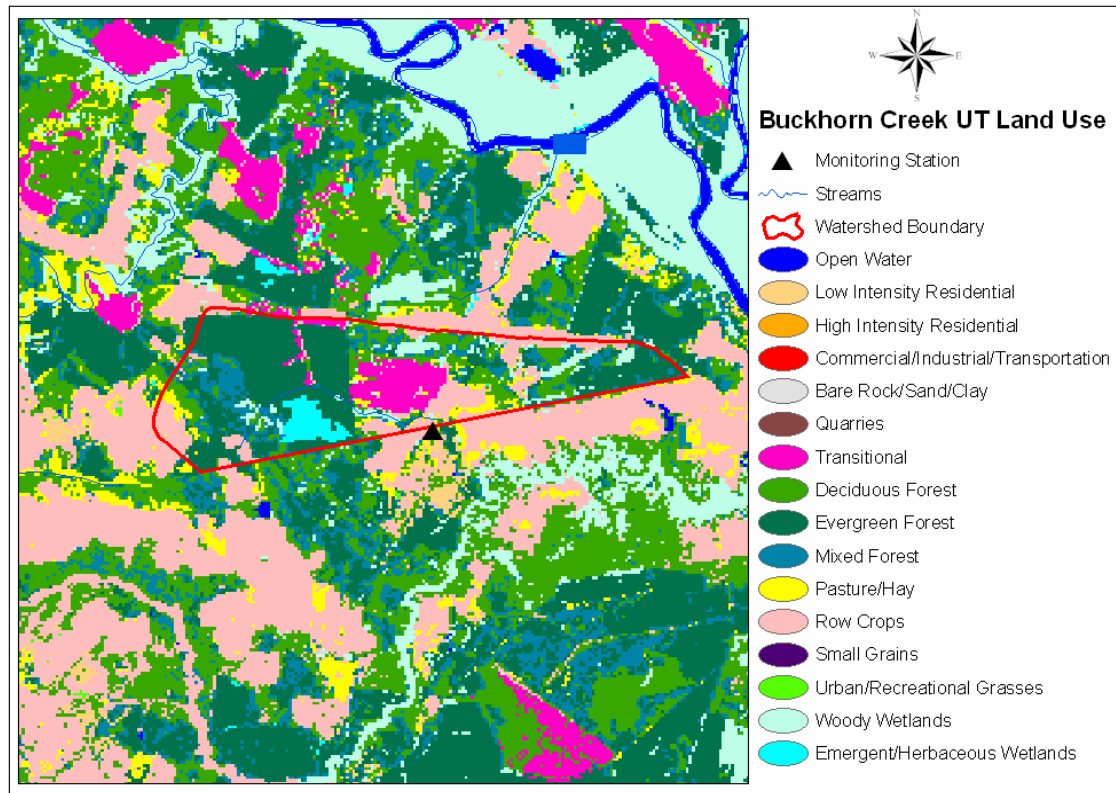
The Buckhorn Creek UT watershed extends approximately 2.0 miles upstream from the VA/NC state line to its headwaters. The watershed is approximately 1,226 acres in size and is predominately forested (63.1) and agricultural (15.9 percent). The agricultural area includes 11.8 percent row crop and 4.06 percent pasture/hay land. Other uses in the watershed are comprised of 2.61 percent open water, 8.63 percent transitional areas, 6.0 percent woody wetlands, and 3.77 percent herbaceous area. Land use is

described in Table 3. A map of the distribution of land use in the watershed (Figure 2) shows that agriculture and forest land cover the majority of the watershed with little to no urban land present.

Table 3. Land use in the Buckhorn Creek UT watershed.

Landuse	Acres	Percent of Total
Open Water	32.0	2.61
Transitional	105.9	8.63
Deciduous Forest	162.6	13.26
Evergreen Forest	459.0	37.44
Mixed Forest	152.3	12.43
Pasture/Hay	49.8	4.06
Row Crops	144.6	11.80
Woody Wetlands	73.6	6.00
Emergent/Herbaceous Wetlands	46.3	3.77
TOTAL:	1226.1	100
	1.91 sq. miles	

Figure 2. Land use in the Buckhorn Creek UT watershed.



3. DESCRIPTION of WATER QUALITY PROBLEM / IMPAIRMENT

Buckhorn Creek UT was listed as impaired on Virginia's 2002 303(d) Report on Impaired Waters, and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 2003, 2004) due to violations of the State's water quality standard for dissolved oxygen and pH.

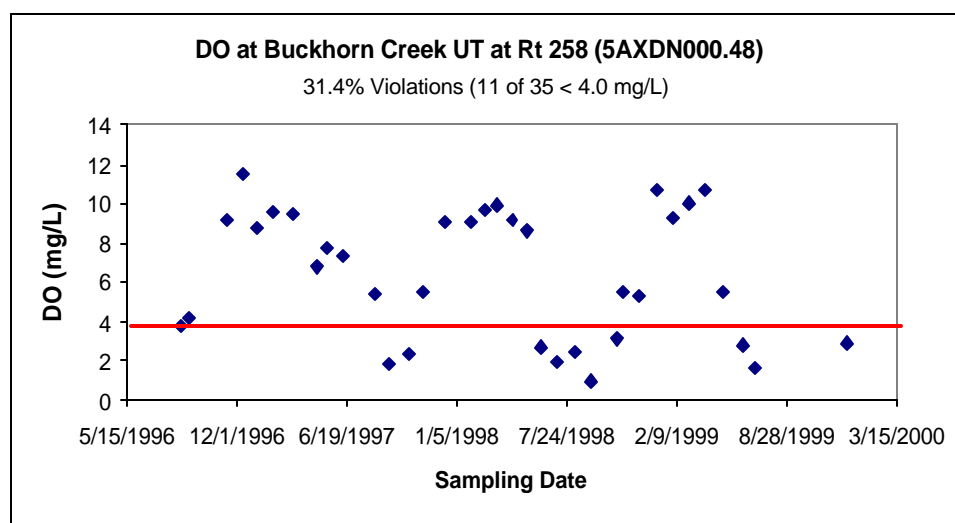
VADEQ obtained a total of 35 DO data points, with 11 water quality standard violations (31.4%) at station 5AXDN000.48 (see Figure 1) from August 21, 1996 through December 15, 1999 (Table 4).

Table 4. DO data collected by VADEQ on Buckhorn Creek UT at Rt 258.

Station	Date of First Sample	Date of Last Sample	Number of Samples	Average mg/L	Minimum mg/L	Maximum mg/L	Number of Violations
5AXDN000.48	8/21/1996	12/15/1999	35	6.41	1.00	11.50	11

A time series graph of all data collected at station 5AXDN000.48 shows the DO concentrations ranging from 1.00 mg/l to 11.50 mg/l (Figure 3). From January 1992, dissolved oxygen measurements were collected using electronic field probe meters. The horizontal line at the DO = 4.0 mg/l mark represents the minimum water quality standard. The data points below the DO = 4.0 mg/l line illustrate violations of the water quality standard.

Figure 3. Time series of DO concentrations at Buckhorn Creek UT at Rt 258, 5AXDN000.48.



3.1 Associated Mainstem and Tributary site DO

VADEQ has no other mainstem or associated tributary monitoring stations in the Buckhorn Creek UT watershed that contain DO data.

4. WATER QUALITY STANDARD

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the

Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criterion. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Buckhorn Creek UT must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Standard

The applicable water quality standard for DO in the Buckhorn Creek UT watershed is an instantaneous minimum DO of 4.0 mg/l.

Table 5. Applicable water quality standards.

Parameter	Minimum, mg/l	Maximum, mg/l
DO	4.0	na

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. ASSESMENT of NATURAL CONDITIONS AFFECTING LOW DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen-restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, rippleless waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

- Step 1. Determine slope and appearance.
- Step 2. Determine nutrient levels.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if Buckhorn Creek UT should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen-restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to

determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. VADEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large input of plant material that consumes oxygen as it decays. The decaying vegetation in swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols, and partially degraded polyphenols, build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII Swamp Water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are

less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII Swamp Water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from VADEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line).

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
 If wetlands are present along stream reach AND
 If no point sources or only point sources with minimal impact on DO and pH AND
 If nutrients are < typical background
 ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
 ❖ average total nitrogen (TN) less than 1.0 mg/L, and
 ❖ average total phosphorus (TP) are less than 0.1 mg/L AND
 For DO: If seasonal fluctuation is normal AND
 For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
 → assess as category 4C in next assessment
 → initiate WQS reclassification to Class VII Swamp Water
 → get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. There is no long-term flow gaging station in the Buckhorn Creek UT basin.

The 7Q10 flows for the Buckhorn Creek UT DO station may be estimated by a drainage area comparison between 5AXDN000.48 and the drainage area and 7Q10 flow at the North Meherrin River near Lunenburg, VA gaging station (USGS #02051000) located approximately 65 miles northwest of 5AXDN000.48. The 7Q10 for North Meherrin River near Lunenburg, was used with a drainage area ratio with the DO site, yielding a 7Q10 flow of 0.02 cfs at 5AXDN000.48.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

At station 5AXDN000.48 on Buckhorn Creek UT, flow was less than the 7Q10 of 0.02 cfs for 1 day in September 1997; 3 days in July, August and September 1998, and 2 days in June and August 1999. During this time period, no DO measurements were recorded, so there were no data points eliminated from the data set.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

There were no discharge measurements made at the Rt. 258 bridge, 5AXDN000.48, the original 303(d) listing station. The hydrologic slope from the 49 ft. topographic contour at rivermile 2.00, located 1.52 mi upstream of the Rt. 258 bridge, downstream to the 33 ft. topographic contour at rivermile 0.00, located at the VA/NC state line is estimated at 0.15%, which is considered low slope. These locations comprise the approximate upstream and downstream boundaries of this low slope segment on mainstem Buckhorn Creek UT. The low slope in this 2.00 mile segment contributes no human impact. This low slope segment encompasses 100% of the Buckhorn Creek UT reach from its headwaters to the VA/NC border. Decomposition of the large inputs of vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

Visual inspections from the bridge at Rt 258 revealed large swamp areas with heavy tree canopy. There are large inputs of decaying vegetation from areas of forested land with heavy tree canopy throughout the watershed. (Figures 4-6).

Figure 4. Buckhorn Creek UT at Rt 258, May 2006.



Figure 5. Buckhorn Creek UT at Rt 258, May 2006.



Figure 6. Buckhorn Creek UT at Rt 258, May 2006.



5.3 Instream Nutrients

The VADEQ collected nutrient data from station 5AXDN000.48 from August 1996 to December 1999. The average nutrient concentrations are near or below the USGS (1999) national background nutrient

concentrations in streams from undeveloped areas with levels of Nitrate ≤ 0.6 mg/l; Total Nitrogen (TKN + $\text{NO}_3 + \text{NO}_2$) ≤ 1.0 mg/l; and Total Phosphorous ≤ 0.1 mg/l (Table 6). While average TN is just above the USGS background level, the watershed is predominately forested and wetlands (72.9 percent), with agricultural land use dispersed in row crops evenly throughout the watershed at 11.8 percent. Decaying organic vegetation in the water will cause an increase in Ammonia as N and Total Kjeldahl Nitrogen. Since TKN is used to calculate Total Nitrogen, this number will also be elevated. Therefore, these nutrient levels are not indicative of human impact.

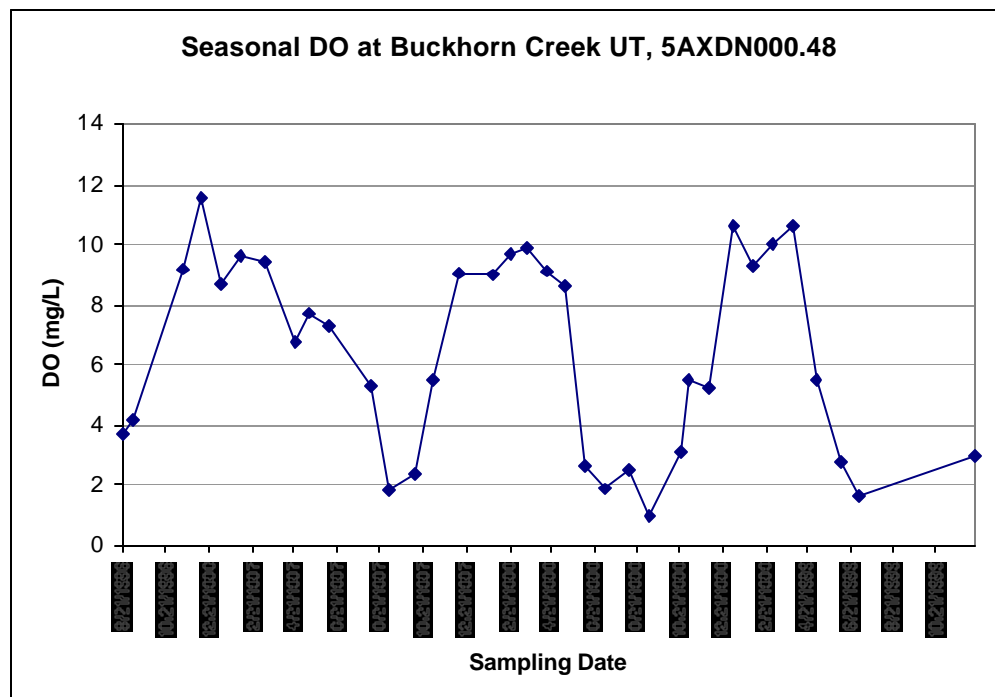
Table 6. Instream nutrients of Buckhorn Creek UT, 5AXDN000.48

Parameter	Average Conc.	Background	Number
Total Phosphorus	0.1 mg/l	<0.1 mg/L	(n=37)
Orthophosphorus	0.06 mg/l		(n=37)
Total Kjeldahl Nitrogen	1.07 mg/l		(n=37)
Ammonia as N	0.11 mg/l		(n=37)
Nitrate as N	0.5 mg/l	<0.6 mg/L	(n=37)
TN (TKN + $\text{NO}_3 + \text{NO}_2$)	1.76 mg/l	<1.0mg/L	(n=37)

5.4 Natural Seasonal DO Fluctuation

Buckhorn Creek UT exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high (Figure 11).

Figure 7. Seasonal variations in DO at Buckhorn Creek UT at Rt 258, 1996-1999.



5.5 Impact from Point Source Dischargers and Land Use

There are no permitted point source discharges in the Buckhorn Creek UT watershed.

Residential and high use industrial areas are not significant contributors of the land base composition, an insignificant portion of the watershed. The watershed is predominately forested and wetlands (72.9 percent), with 2.6 percent open water. This land use was considered not indicative of human impact.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50%) AND

If wetlands or large areas of forested land are present along stream reach AND

If no point sources or point sources with minimal impact on DO AND

If nutrients are < typical background

❖ average (= assessment period mean) nitrate less than 0.6 mg/L

❖ average total nitrogen (TN) less than 1.0 mg/L, and

❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural conditions

→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water

→ get credit under consent decree

Buckhorn Creek UT from rivermile 2.00 downstream to the VA/NC state line exhibits low slope (0.15%) and has large areas of forested land with swamps and heavy tree canopy. Large inputs of decaying vegetation from areas of forested land with swamps, and heavy tree canopy throughout the watershed increase oxygen demand and lower DO in the stream. These are not considered anthropogenic impacts.

Buckhorn Creek UT exhibits nutrient concentrations near or below national background levels in streams from undeveloped areas, which is not indicative of human impact. Decaying organic vegetation will cause increased Total Kjeldahl Nitrogen levels, which then directly relate to an elevated Total Nitrogen level.

Buckhorn Creek UT exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no permitted dischargers in the Buckhorn Creek UT watershed.

Based on the above information, a change in the water quality standards classification to Class VII Swamp Water due to natural conditions, rather than a TMDL, is indicated for Buckhorn Creek UT from rivermile 2.00 downstream to the VA/NC state line at rivermile 0.00. If there is a 305(b)/303(d) assessment prior to the reclassification, Buckhorn Creek UT will be assessed as Category 4C: Impaired due to natural conditions, no TMDL needed.

7. PUBLIC PARTICIPATION

VADEQ performed the assessment of the Buckhorn Creek UT low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

8. REFERENCES

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Rosier Creek Watershed, Virginia. 2003.

SRCC (Southeast Regional Climate Center)

http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html (Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia 2002 303(d) Report on Impaired Waters. 2003.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 305(b) / 303(d) Integrated Report. 2004

Appendix A

Glossary

GLOSSARY

Note: All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

7Q10. The lowest streamflow for seven consecutive days that occurs on average once every ten years.

Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.

Anthropogenic. Pertains to the [environmental] influence of human activities.

Background levels. Levels representing the chemical, physical, and Bacterial conditions that would result from natural geomorphological processes such as weathering or dissolution.

Best management practices (BMPs). Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

Confluence. The point at which a river and its tributary flow together.

Contamination. The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.

Designated uses. Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Dilution. The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.

Direct runoff. Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.

Discharge. Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

Discharge permits (under VPDES). A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.

Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Effluent. Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.

Effluent limitation. Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.

Existing use. Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Hydrologic cycle. The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.

Hydrology. The study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

In situ. In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.

Margin of safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the

receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a $TMDL = LC = WLA + LA + MOS$).

Mean. The sum of the values in a data set divided by the number of values in the data set.

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Monitoring. *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

Narrative criteria. *Nonquantitative guidelines that describe the desired water quality goals.*

National Pollutant Discharge Elimination System (NPDES). *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

Non-point source. *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

Numeric targets. *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Peak runoff. *The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

Permit. *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.

Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, Bacterial, chemical, and radiological integrity of water.

Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).

Raw sewage. Untreated municipal sewage.

Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

Restoration. Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.

Riparian areas. Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

Runoff. That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).

Stakeholder. Any person with a vested interest in assessment of natural condition or TMDL development.

Standard. In reference to water quality (e.g. pH 6 – 9 SU limit).

Storm runoff. *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Surface area. *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

Surface runoff. *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

Surface water. *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

Topography. *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

Total Maximum Daily Load (TMDL). *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

Tributary. *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

Variance. *A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.*

DCR. Department of Conservation and Recreation.

VADEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Wastewater. *Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.*

Wastewater treatment. *Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

Water quality. *The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

Water quality criteria. *Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.*

Water quality standard. *Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.*

Watershed. *A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*